THE

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ARTS, MANUFACTURES,

AND

AGRICULTURE.

No. XXXIV. SECOND SERIES. March 1805.

Specification of the Patent granted to THOMAS PORTHOUSE, *of Hall Garth, in the Parish of Houghton-le-Skern, in the County of Durham, Flax-spinner; for a Machine for hackling Flax and Hemp, and at the same Time carding the Tow.* Dated October 6, 1804.

With a Plate.

TO all to whom these presents shall come, &c. Now KNOW YE, that in compliance with the said proviso, I the said Thomas Porthouse do by these presents describe and ascertain the nature of my said invention, and the manner in which the same is to be performed, by the annexed drawing, (Plate XI.) and the following description thereof; that is to say: The machine consists of the following parts. Part the first, which I call jaws, (see Figs. 1 and 2,) for fixing or holding one end of the handful or parcel of the flax or hemp in a firm manner, whilst the opposite end of the handful or parcel of flax or hemp undergoes the subsequent operation of hackling. Part the second, which I call a turn-table, on the edge of which

which the jaws are fixed, (see Figs. 3 and 4,) for introducing into the machine the handfuls or parcels of hemp or flax in the raw state, also for changing the side of the flax or hemp during the operation; and when the handfuls or parcels of flax or hemp become sufficiently dressed for, turning them out of, or from, the acting part of the machine, for the purpose of allowing the handfuls already dressed at one end to be taken out of the jaws, and changed or turned to the contrary end, or replacing them by undressed handfuls, as the case shall require. Part the third, an instrument, which I call a porcupine, (see Figs. 5 and 6,) for dressing or splitting the fibres of the flax or hemp, and at the same time taking out the tow or shorts from the staple flax or hemp, and delivering it upon small conical cards, for the purpose of carding the same, in a manner herein-afterwards to be described. Part the fourth, conical or bevel-faced cards, (see K, Figs. 9 and 11,) for receiving the tow from the porcupine, and carding the same, which is afterwards collected by rollers, nearly in the same manner as from the common carding-engine. Part the fifth, machinery for giving the requisite velocity to each of the foregoing parts of my said machine (see Figs. 11 and 9).

The jaws (see Fig. 1, Plate XI.) are made of cast-iron, or other metal, and represented as open, ready for receiving the handful of flax or hemp.

Fig. 2, shews how the flax or hemp is fixed into the jaws ready for the subsequent operation of hackling or dressing. Three of these jaws are fixed upon the edge or outer rim of the turn-table, at equal distances from each other.

In Fig. 3 two jaws are represented, in which A shews the jaws open, and B the jaws shut, with the flax or hemp in them. C the table, which is made of wood or metal,

metal, about three feet diameter, and mounted upon an iron shaft, having three studs Z Z Z, (see Fig. 4,) of iron, about three-fourths of an inch diameter, firmly fixed in their upper side at about six inches distant from the centre, and equi-distant from each other, and projecting about two inches. Several of these turn-tables are placed at convenient distances, and ranged in a circular direction round one common centre, as represented in Fig. 4, suitable for being acted upon by the porcupines D, more particularly delineated in Figs. 5 and 6; in which D is the body or barrel of the porcupine, made of wood, and about nine inches long and six inches diameter, stuck or filled with steel pins E, similar to those used in the common hand hackle, and projecting in radii from the body or barrel of the porcupine, of different lengths and fineness, to suit the flax or hemp as the dressing advances in fineness during the operation. Those pins which are intended to strike the raw flax or hemp in the first instance, are about two inches in length, and set in the barrel or body of the porcupine at about the same distance as those used in the hand hackles for flax or hemp of the same kind, and gradually increase in length and fineness round the whole of the circumference of the barrel or body of the porcupine: the longest pins are about a quarter of an inch longer than the shortest, and the finest pins are set about the same fineness as those used for finishing the same kind of flax or hemp by hand. And as the tow is collected upon the pins of the porcupine, the pieces or bars of iron or other metal F, called droppers, (about one inch broad, a quarter of an inch thick, and nine inches in length, placed in a longitudinal direction amongst the pins of the porcupines,) drop down upon the tow; and as the porcupine revolves round its own axis these droppers, by their own weight, drop down, and gra-

dually push the tow from the points of the pins as they advance in their progressive motion round their own axes, but are prevented from falling too far by a plate at each end of the porcupine, about ten inches diameter, and one-eighth of an inch thick, having grooves cut in it, in which the ends of the droppers slide, as represented in Fig. 8; in which G is the plate, H the grooves, I a dropper, falling down and pushing off the tow, and J the dropper restored to its place, and leaving the pins at liberty for acting in the hemp. The tow thus pushed off the pins of the porcupine is collected by the conical cards, as represented in Figs. 9 and 11, in which K is a conical barrel, about twelve inches long and about fifteen inches diameter at the thickest end, and ten inches at the smaller end, covered on its superficies by a card of the usual fineness for carding tow, and placed with its smaller end towards the centre of the machine, as represented in Figs. 9 and 11; and its upper side a little lower than the under side of the porcupine, for the purpose of collecting the tow from the lower side of the porcupine, as the same is pushed off by the droppers, and ought at these dimensions to make about five revolutions *per* minute.

L, Fig. 10, is a fixed angular piece of wood, (its base about fifteen inches in length and six inches in breadth, and its height about ten inches,) which I call a preventer, placed close to the superficies of the conical card K, the side of which angular piece of wood next the card K is curved so as to fit the card K, and extending over about a fifth part of its surface, serves to keep the tow from escaping from the card K until it arrives at the angle M, where it is received by the main bevel card wheel N, Figs. 9, 10, 11, in which O are the cards, as they are placed upon the bevel of the wheel, leaving open spaces between the cards for the purpose of letting out the dust.

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This wheel N is about six feet diameter, and revolves at the rate of about sixty revolutions *per* minute, and receiving the tow from the conical cards K at the angle of the preventer at M, it is thereby carded as it passes between them; and the lower side of the preventer being lined or covered with a card, whose hooks point in a contrary direction to those of the cards on the main bevel card wheel, assists in carding the tow, and serves also to keep it close and compact into the cards O.

P, Figs. 9 and 10, represents a conical brush, twelve inches long, twelve inches diameter at the largest end, and nine inches diameter at the smallest end, its bristles pointing in radii from its centre, and its axis pointing in a line towards the centre of the machine. The superficies of the brush act upon the main card, and ought to move with a velocity of about one-fifth quicker at its surface, for the purpose of raising up the tow from the hooks of the main card, in order that it may be received from the conical doffing card Q, Figs. 9 and 11. This card is about thirteen inches long, eighteen inches diameter at the largest end, and eight inches at the small end, and placed with the largest end towards the centre of the machine. The hooks of the card must point in a contrary direction to those of the main card; and in proportion thereto ought to make about ten revolutions *per* minute, by which, as it is going slower than the main bevel card wheel, which is acting against it, the tow is caught upon its hooks, and may be collected therefrom in a continued sliver by cylindrical rollers, whose superficies move with an equal velocity with the superficies of the larger end of the conical doffing card Q, nearly in the manner as is usually done from the cylinders of the carding-engines now in use.

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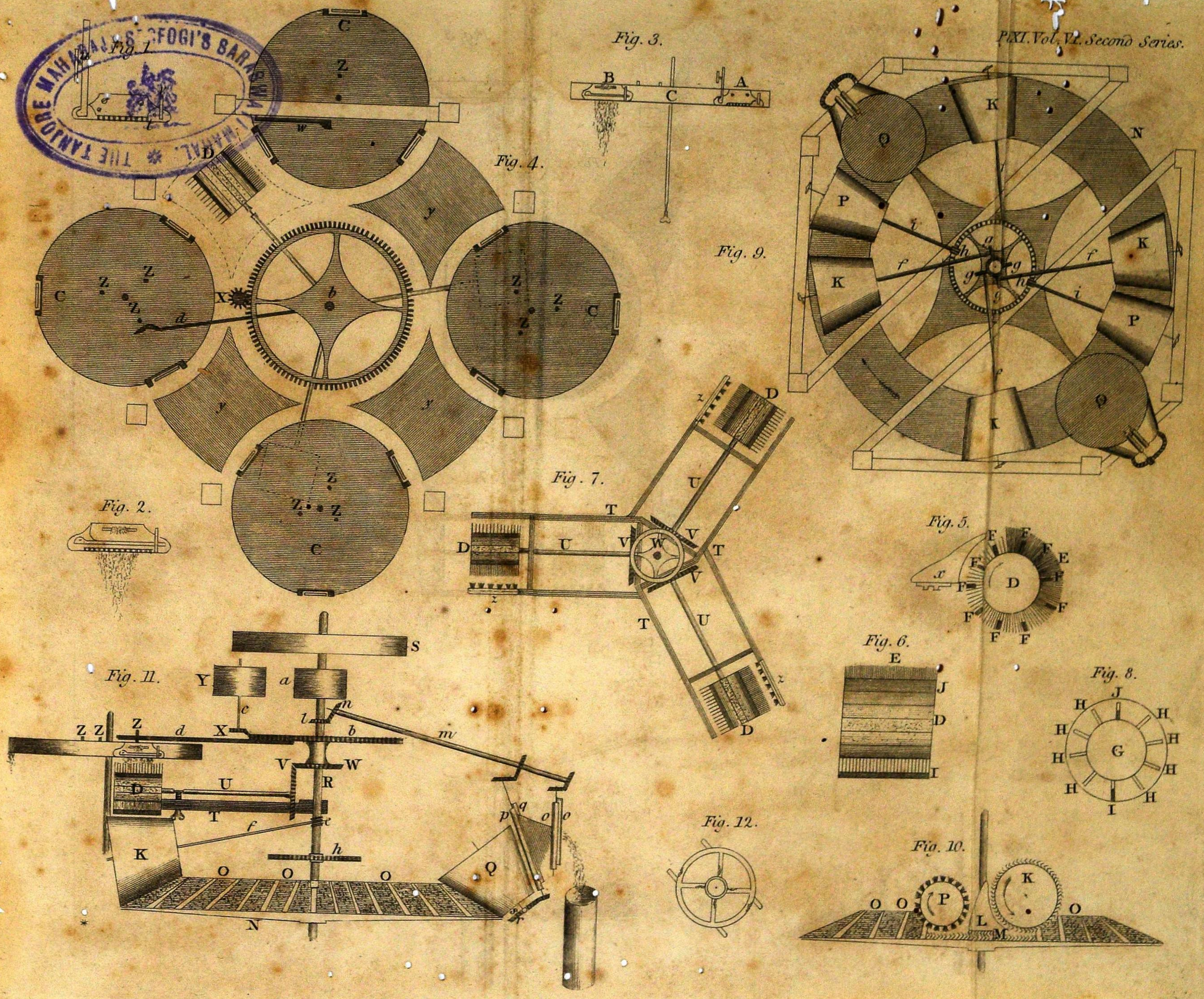
The movements for the different parts of this machine may be obtained in various ways; that which I have adopted is as follows. In the centre of the machine, of which Figs. 4 and 9 are plans, and Fig. 11 an elevation, I place an upright shaft of iron R, about six or seven feet long and about three inches thick, resting in a step of metal at the bottom end, and supported at the upper end by a wood framing to keep it steady, but so as the shaft itself may be easily turned round therein. At the upper end of the shaft R, I fix a pulley S, by which this shaft is put in motion by a strap leading from the mill. Near the middle of the shaft at R is firmly fixed thereon a strong cast-iron frame, for receiving three spindles, a plan of which is delineated in Fig. 7, in which T T T represent the cast-iron frame, and U U U the spindles, D D D the porcupines, firmly fixed upon the ends of the spindles U U U, but the spindles themselves are not fixed fast, but are at liberty to move round upon their own axes. By the motion of the shaft R round its own axis, the frame T T T, and the spindles U U U, and the porcupines D D D, placed thereon, are carried round in their orbit at the speed of about sixty revolutions *per* minute, by which means the three porcupines D D D, striking alternately against the handfuls of flax or hemp presented to them by the turn tables C, Figs. 4 and 11, split the fibres of the hemp or flax, and at the same time collect the tow or shorts upon the pins of the porcupines, which is again collected therefrom by the conical cards for carding the same, as before described. Upon the spindles U U U are bevel-toothed wheels V V V, whose teeth are inserted between and are acted upon by the teeth of a similar wheel W, placed upon a round part of the shaft R, but whose motion round its own axis

axis is slower than the shaft R, in the proportion of about twenty for the shaft R to one of the wheel W; by which means the wheel W becomes so nearly stationary as to act upon the wheels V V V nearly as a fixed or dead wheel would act, thus producing a rotary motion to the spindles U U U and the porcupines D D D, as they are carried round by the frame T T T upon the shaft R; and by this means the porcupines D D D, presenting a change of surface to the flax or hemp which gradually passes from the coarser set and short pins towards the longest and finest set pins, until the pointer wheel, hereafter to be described, and the wheel W, to which it is fixed, has made one entire revolution, which in general may be about twenty revolutions of the main shaft R; but this must be varied according to the quantity of flax or hemp to be hackled, and is done either by changing the wheel X, Figs. 4 and 11, or altering the diameters of the pullies Y and *a*, Fig. 11; coarse flax or hemp requiring fewer strokes of the porcupines, and fine flax or hemp requiring more, and which is to be adjusted by the operator. This rotary motion of the porcupines also presents a continued change of their surface to the conical cards K, and produces an alternate motion to the droppers F, Figs. 5 and 6, by which means the tow is thereby pushed out from amongst the teeth of the porcupines, and is collected by the conical cards K, as before described. Upon the upper side of the wheel W, Fig. 11, is firmly fixed a socket of metal; and upon the upper end of that socket is also firmly fixed another wheel *b*, about thirty inches diameter, which I call the pointer wheel, whose teeth are inserted between and are acted upon by the teeth of the wheel X, whose diameter is about one inch and a half. This wheel X is firmly fixed upon a spindle *c*, upon which is the pulley Y, which by a strap

a strap from the pulley *a* upon the shaft R has its relative motion given to it; which motion may be varied by changing the wheel X, or changing the diameter of the pullies Y and *a*, or by making these pullies into cones, reversing the ends of them, and sliding the strap by a lever, for that purpose, to the upper or lower end of those cones. Upon the lower side of the wheel *b* is firmly fixed a bar of iron *d*, Figs. 4 and 11, which I call a pointer, projecting in a radical line from the centre of the wheel *b*, and extending itself out nearly to the centre of the turn-table. This pointer is for the purpose of pushing the turn-tables round upon their axes by its action against the pins Z Z Z, and by this means changing and turning the handfuls of flax or hemp as before described, and according to the velocity of this wheel *b* and pointer *d*, which may be varied as before said by a change of wheels, or by sliding the strap along the cones, such will be the number of strokes given by the porcupine against the flax or hemp, and thus may the fineness of the cut be regulated. Upon the shaft R, Figs. 9 and 11, a little below the cast-iron frame, is firmly fixed an endless screw *e*; and upon the spindles *f* are also firmly fixed spur wheels *g*, having eighteen teeth, which teeth are inserted between and are acted upon by the worm or threads of the screw *e*, which, by the revolution of the shaft R, gives motion to the spindles *f* and the conical cards K (fixed firmly thereon), in the proportion of three and one-third revolutions of the conical card K to sixty revolutions of the shaft R, as before described. Near the lower end of the shaft R is firmly fixed thereon the main bevel card wheel N; and a little above that wheel, is also firmly fixed upon the shaft R a bevelled-toothed wheel *h*, about twenty-one inches diameter; and upon the spindle *i*, Fig. 9, is also firmly fixed another bevelled-toothed

THE TANJORE MAHARAJA SERFOGI'S SARASWATI MAHAL.



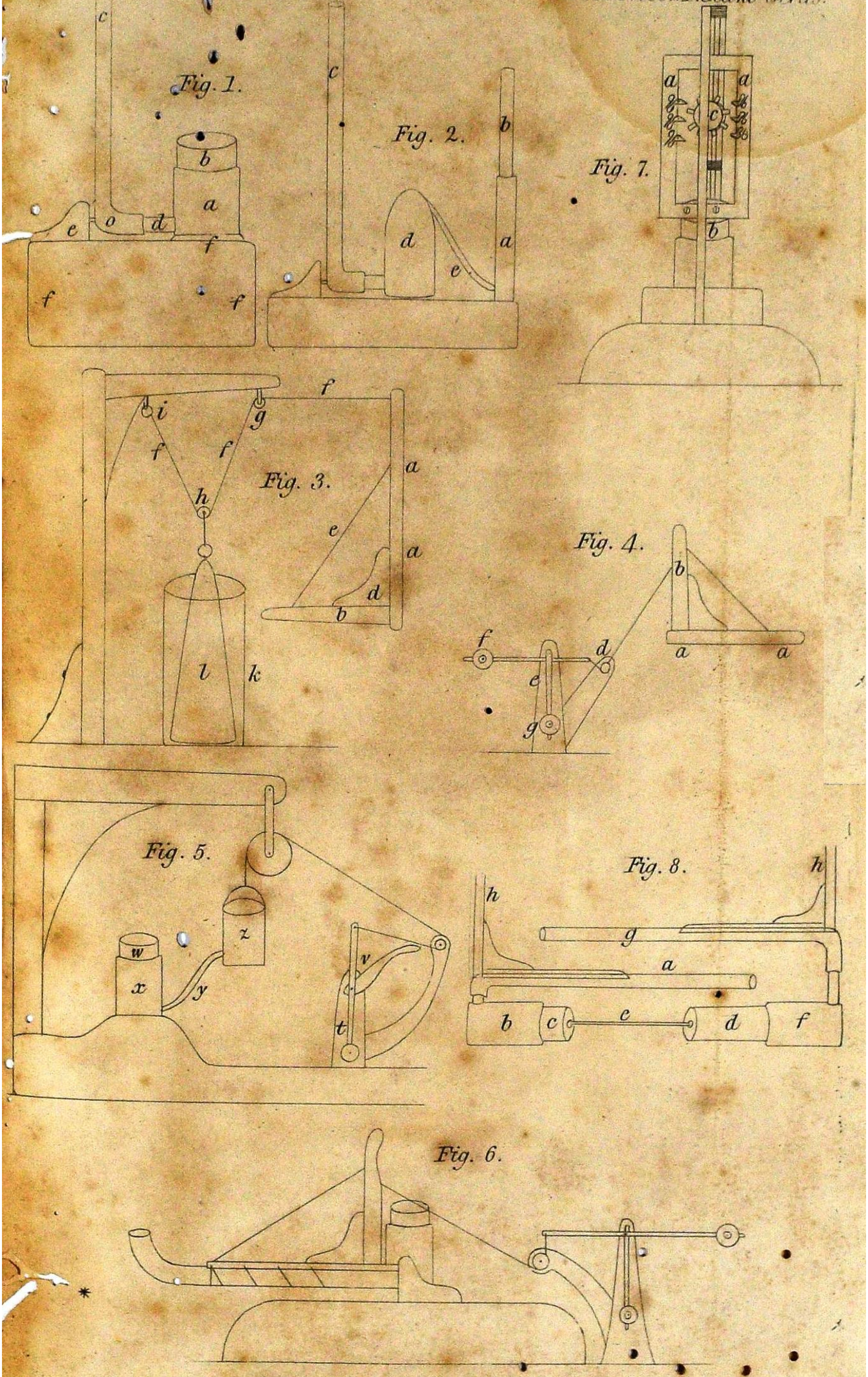


Fig. 1.
Fig. 2.
Fig. 7.
Fig. 3.
Fig. 4.
Fig. 5.
Fig. 8.
Fig. 6.

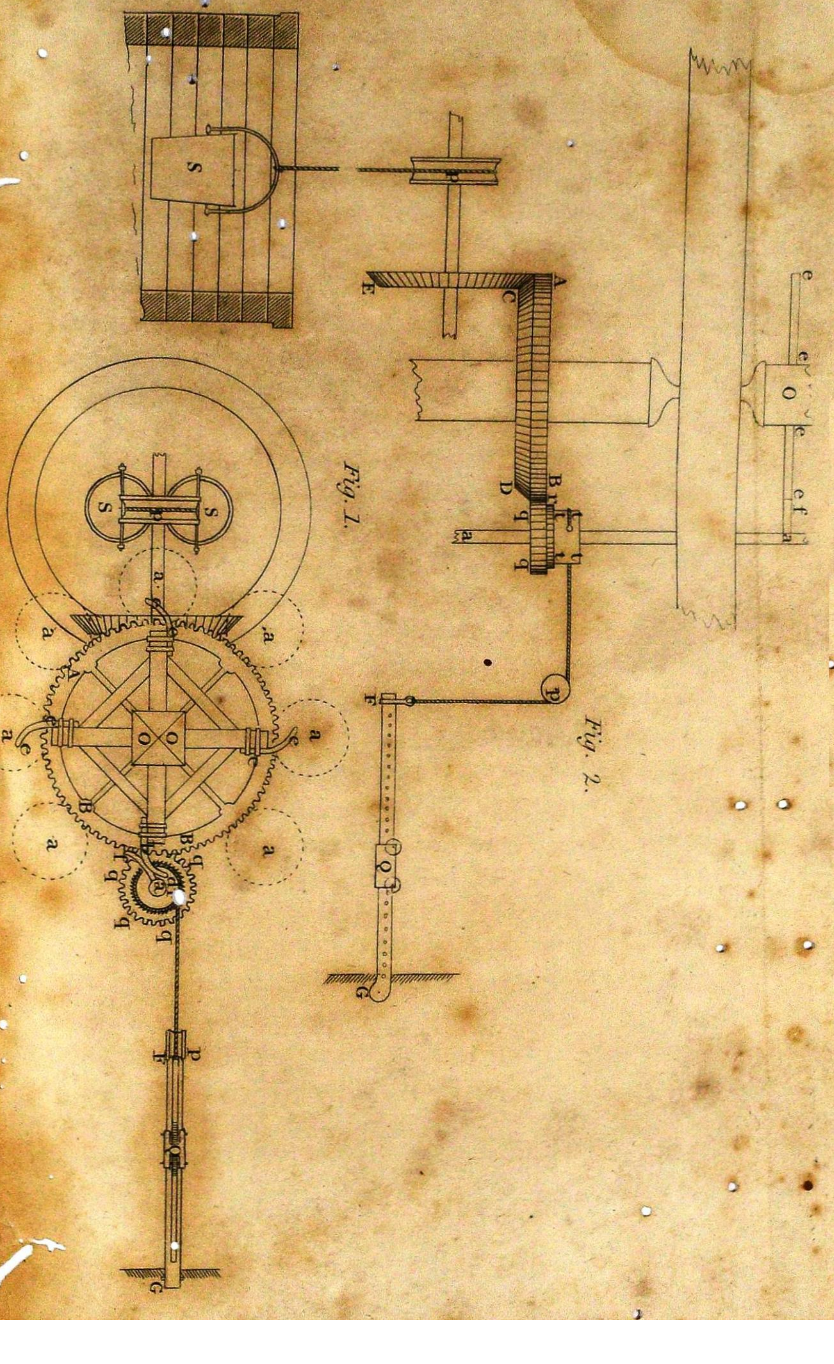


Fig. 1.

Fig. 2.

toothed wheel *k*, about three inches diameter, the teeth of which are inserted between and are acted upon by the teeth of the wheel *h*, which, by the revolution of the shaft R, gives motion to the spindle *i* and the conical brush P, firmly fixed thereon, in the proportion of four hundred and twenty revolutions of the conical brush P to sixty revolutions of the shaft R and the main bevel card wheel N, as before described. Upon the shaft R, and a little above the wheel *b*, is firmly fixed a small bevel-toothed wheel *l*; and upon the spindle *m* is also firmly fixed another similar bevel wheel *n*, the teeth of which are inserted between and are acted upon by the teeth of the wheel *l*, which, by the revolution of the shaft R, gives motion to the spindle *m*, which also in the same manner gives motion to the rollers *o o*, and rollers *p q*. The roller *p*, by a wheel fixed firmly upon its lower end, also gives motion to the wheel *r*, which, being likewise firmly fixed on the spindle *s*, gives motion to the conical doffing card Q, in the proportion of ten revolutions of the doffing card Q to sixty of the shaft R and main bevel card wheel N fixed thereon, as before described.

The machine thus in motion, and the turn-tables adjusted by the screw on which the foot or lower axis of the turn-table rests, so as the porcupines just pass clear of the under-side of the tables; and the porcupines having been adjusted by screws under their pivots, so as their lower sides pass just clear of the conical cards K, those jaws which are outside the machine must be fed with handfuls or parcels of flax or hemp, of two, three, four, or more ounces each, according to the quality of the flax or hemp, by taking the parcel to the turn-table, and after opening the upper jaw, which is notched in the same manner as the under jaw, (see *t*, Fig. 1,) for the

purpose of keeping the flax or hemp spread broad, fold one end of the flax or hemp over the head or cross part of the jaw, and two or three times round the part *u*, and then press down the jaw within the hook or catch *v*, it will be holden firmly. This done, the pointer *d* will move the turn-table forwards one-third of a revolution, and thus draw the handful or parcel of flax or hemp within the orbit or circular range of the porcupines; and the turn-tables being held fast by catches, as at *w*, see Fig. 4, where one only is represented, the points or pins of the porcupines striking against the parcels of flax or hemp, and at the same time prevented from going too deep by the fence or foreboard *x*, (see Fig. 5,) the top edge of which is to be level with the points of the short pins of the porcupines, will gradually begin to dress or hackle the same, which, after receiving about twenty strokes from each porcupine, the pointer will have again advanced to that turn-table which it first began with, and by its action loosening the catch *w* the turn-table will be again driven one-third of a revolution round its axis, and the handful of flax or hemp will advance forwards, and present its other side to the action of the porcupines; but in this instance, as the stroke of the porcupine impels the handful or parcel of flax or hemp from or beyond the superficies of the turn-table, there are fixed what I call end boards, see *y*, Fig. 4, to prevent its escape from the action of the pins of the porcupines. (One of the end boards is omitted in the drawing to shew a porcupine). After receiving about twenty more strokes from each of the porcupines, the turn-tables will be again pushed forward by the pointer, the remaining third of a revolution round its axis, and the handful of flax or hemp which was first affixed to the jaws, will make its exit from the machine, having one end, or half of it, completely

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pletely hackled, which, when the operation is repeated at the other end of the handful, will be finished; and its tow or shorts being received by the conical cards K will be carded by the card N, and delivered by the conical doffing card Q and rollers *p q* and *o o* in a continued sliver, as before described.

Upon a part of the iron frame T T T, Fig. 7, are fixed three narrow brushes, about nine inches long, placed with the ends of the bristles downwards, and rather lower than the pins of the porcupines D, and about three inches behind them, (see *z z z*), for the purpose of assisting the separation of the tow from the pins of the porcupines, and sweeping it into the teeth of the conical cards K.

Fig. 12, is an iron frame, to be fixed upon the long rails in Fig. 9, for the purpose of supporting the axis of the conical cards K and the axis of the conical brushes P.

The machine must be cased to keep in the dust, and the spindles and pivots must be secured from the short fibres which fly off in working.

In witness whereof, &c.

Specification of the Patent granted to EDWARD STEERS, *of the Inner Temple, London, Esquire; for his Invention of an Engine producing a Force by the Impetus which the Parts of a fluid Body have to an equal Altitude, applicable to the working of all Sorts of Machinery.*

Dated December 19, 1804.

With a Plate.

TO all to whom these presents shall come, &c. NOW KNOW YE, that in compliance with the said proviso, I the said Edward Steers do hereby declare and describe my said invention to be an engine which contains a new method of giving activity to a body of water, or other liquid

liquid contained in it, so as to produce a force from the well-known property of the pressure of liquids in all directions, which may be conveniently applied to the purpose of working machinery. The method consists in suddenly producing or increasing an inequality in the altitude of the parts of the fluid body contained in the engine by the descent and ascent of a pipe, cylinder, or other vessel capable of holding liquid, by either turning on a hollow projection, joint, or water way, which connects it with another cylinder or vessel, as in the drawing Fig. 1, (Plate XII.) or by turning in an orifice of the other cylinder or vessel, or by having a flexible pipe or sliding pipe, (similar to the joints of a telescope,) or other water way, connecting it with the other cylinder or vessel, so that it can be raised and lowered, as represented by Fig. 5.

Description of Fig. 1.

a, is a cylinder, open at the top. *b*, is another cylinder, closed at each end, which exactly fills the cylinder *a* with respect to its width, so that no liquid can pass between them. *c o*, is a long pipe, curved at the end *c*, to prevent the escape of liquid, the end *o* turning on a hollow joint or water way into the cylinder *a*. Perhaps it would be better to have the end *o* of the pipe straight, and inserted in an orifice of a box or chamber, made to turn on the water way *d*. *e*, is a support, with a hole in it, to receive a pin fixed at the lower end of the pipe *eo*, (or in a box or chamber in which the end *o* of the pipe is inserted,) that it may the more easily turn on *d*. *fff*, are supports for the whole. Let the pipe *c o* be lowered to a horizontal position, and let water be poured in at the end *c* till the pipe be full; then if it be raised again perpendicularly the water will run into the cylinder *a*, and by its pressure raise the cylinder

linder *b* with a very powerful force, which may be applied to the working of all sorts of machinery. When the pipe *l o* is again lowered to a horizontal position, the water will run from the cylinder *a* into the pipe, and the cylinder *b*, if no air can get under it, will be pressed down with some force by the atmosphere; but a weight or spring should be applied to the top of it, to make the pressure down equal to the upward pressure, that the working power (the cylinder *b*) may have an alternate motion of equal force applicable to the working of machinery. Or two engines may be made use of, one to act upon the top of the other by means of a lever; or, if placed so that the working power may move horizontally, one may act upon the other by means of a straight bar, as represented by Fig. 8. It may be seen that the cylinders *a* and *b*, above described, (see Fig. 1,) are similar to the machines represented in Nicholson's Treatise on the Science of Hydrostatics, to shew the upward pressure of fluids; and that the bag with boards at each end, described hereafter, is similar to the figure of the machine which Ferguson in his lectures on hydrostatics calls the Hydrostatic-bellows. The pipe, cylinder, or other vessel, being made to descend and ascend, is the invention which, by occasioning a body of liquid to flow in and out of the above-mentioned machines, renders them engines applicable to the purpose of working machinery by the liquid contained in the said engines without requiring a constant external supply. If it be requisite, the engine may be made with two or more pipes, cylinders, or other vessels, to ascend and descend. It may sometimes be found an advantage to have the working power acted upon by air instead of liquid, which may be managed in the way represented by Fig. 2. The pipe *c* being raised perpendicularly, the liquid runs from

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it into the vessel *d*, the air from which passes through the channel *e* into the cylinder *a*, and forces up the working power *b*. It will be necessary to have a frame, containing a lever, fixed to the pipe *c o*, (see Fig. 1,) for the purpose of easily lowering and raising it, and also a weight to counteract the weight of the pipe when filling with water in its descent, which may be made similar to the following, so as nearly if not exactly to balance it.

Fig. 3, *a a*, may be made of wood, or any other material proper for the purpose, with a groove from one end to the other to receive the pipe *c o*, (see Fig. 1,) which may be fastened to it by a rope. *b*, is a lever, fixed to *a a*, and if the end *o* of the pipe *c o* be inserted in a box or chamber (as before described), the chamber may be made with a long arm, which may be fastened with screws to the lever *b*. *d*, a stay, to strengthen the frame. *e*, another stay, which may be a rope. *fff*, a rope. *g*, a pulley. *h*, a pulley. *i*, a hook and ring. *k*, a vessel filled with water. *l*, a weight, which should be of rather more than the specific gravity of water, and of sufficient weight to balance the pipe *c o*, (see Fig. 1,) when horizontal and full of liquid. If the lever *b* be raised, the pipe *c o*, (see Fig. 1,) fastened to *a a*, will be lowered, and gradually filled with water, and its weight of course gradually increase; but it will be counteracted by the weight *l*, which is also an increasing weight, for as it rises the part out of the water becomes a weight in air, and consequently has more preponderancy than it had in water. The shape of the weight *l* will regulate the force necessary to counteract the increasing weight of the pipe *c o* (see Fig. 1) when filling with water in its descent, which will be clear by viewing Fig. 3, and considering that as the weight rises out of the water it increases in preponderancy more the second inch than the first it

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rises, so do[illegible] the weight of the descending pipe *c o* the second inch it falls than the first. The shape that may be requisite cannot here be stated, as it will depend upon the dimensions of the pipe *c o*. Another way of balancing the descending and increasing weight of *c o* in its ascent and descent is shewn by Fig. 4, where *a a* is represented in a horizontal position; *c o* is supposed to be fastened to it, and full of water. By inspecting the figure, it is evident that the pendulum *g* does not act at all upon the lever *b*, but the pendulum *f* does with all its weight. If the lever *b* be lowered towards *d*, the pendulum *f* will fall towards *g*, and the pendulum *g* will rise towards *d*, till the pendulums become in equilibrium, when the pipe *c o* will be sufficiently raised, the water having run from it. The ball *g* is intended to regulate the force which is necessary to act upon the lever *b*, which it will do as it shall be placed nearer or farther from the fulcrum; for which purpose, the bar to which it is attached may be made to pass through its centre, so that it may be fixed by a screw to any part of the bar. Another kind of balance for the weight of the pipe *c o* may be made by a wheel similar to the chain-wheel of a watch, with a rope and weight attached to it. This engine may be made in the following way: suppose a bag made of thick leather, or other material capable of holding liquid, kept open by hoops, at any convenient distance from each other, and closed at each end by boards, so as to prevent the escape of any liquid, except at an orifice to admit the water way *d*, (see Fig. 1,) just above the lower board; it will then open and close like a paper lantern, and may supply the place of the two cylinders *a* and *b*, described in Fig. 1; for the other parts of the engine being the same as described in Fig. 1, and the hollow joint *d* inserted in the orifice just above the lower board, if the

pipe

pipe *c o* be placed in a horizontal position, and filled with water, upon it being raised perpendicularly the water will run into the bag, and press up the upper board as it did the cylinder *b*, in Fig. 1. The pipe being again lowered to a horizontal position will occasion the water to quit the bag, and the upper board will be depressed.

Fig. 5. The vessel *z* having been raised, the water has run from it through the flexible pipe *y* into the cylinder *x*, and pressed up the inner cylinder *w*. Now if the lever *v* be pressed down, it will raise the pendulum *t*, which is a balance for the vessel *z*. *z* will be lowered, and filled with water from *x*, and the cylinder *w* will be depressed as the cylinder *b*, in Fig. 1, was described to be.

Fig. 6 shews the Figs. 1 and 4 united, the pipe being horizontal, ready for filling with water.

Fig. 7 represents a mode of producing a rotary motion by an alternate one, which may be made use of when a circular motion is required for the working of machinery by this engine; as the frame *a a* rises by the upward pressure of the cylinder *b*, the catches on the right hand side of the frame take the cogs on the right hand side of the wheel *c*, while the catches on the opposite side of the frame give way to the left hand cogs of the wheel *c*; when the frame falls with the cylinder *b* the reverse takes place with respect to the catches and cogs, by which double operation the wheel *c* is constantly pressed round the same way. At the back of the catches are springs to restore them to their situation after having given way to the cogs; and in the front of them are pins, to prevent their passing that way. If it be found that the catches do not take hold of the cogs sufficiently quick, another set of catches may be placed at the back of the frame *a a*, to take the cogs of another wheel fixed on the same axle-

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tree in such a way that the cogs of one wheel may be opposite to the spaces of the other.

Fig. 8. This drawing represents two engines, the working powers acting upon each other horizontally. The two pipes *a* and *g* being filled with water, if the pipe *a* be raised perpendicularly the water will run into the cylinder *b*, and by its pressure upon the end of the cylinder *c* force it forward, when the cylinder *d*, being attached to *c* by the bar *e*, will be forced into the cylinder *f*; then if the pipe *g* be raised, and *a* lowered at the same time, the water will run into the cylinder *f* and out of the cylinder *b*, and the reverse will take place with respect to the cylinders *c* and *d*. The alternate motion of the bar *e* will be a force applicable to the working of machinery. The pipes *a* and *g* may be made to rise and fall alternately, by means of three cog wheels, one in the middle to work into the two others. The bars *h h* of the frames attached to the pipes *a* and *g*, being axletrees for the two outside wheels, suppose one of the pipes horizontal, the other perpendicular, then if the middle wheel be turned one quarter round, it will raise one pipe perpendicular, and lower the other to a horizontal position.

In witness whereof, &c.

Observations by the Patentee.

The weight of the pipe which is made to ascend and descend can be balanced, therefore the power necessary to raise and lower it is no more than what is sufficient to turn a balance. Since then the power necessary to produce the force is but little, while the force produced is very great, I am of opinion that the engine may be made to continue in action by its own energy, for I think a part of the force produced may be made to supply the producing power by means of the cog wheels.

Specification of the Patent granted to ABRAHAM UNDERDOWN, *late of the Parish of Eling, in the County of Southampton, but now of Braynes-row, Spa-fields, in the County of Middlesex, Gentleman; for a new Mode or Method of making Flour without Grain.*

Dated December 19, 1804.

TO all to whom these presents shall come, &c. NOW KNOW YE, that in compliance with the said proviso, I the said Abraham Underdown do hereby describe and ascertain the nature of my said invention, and in what manner the same is to be performed, as follows; that is to say: I take turnips, potatoes, parsnips, white-beet, and Jerusalem artichokes, and I grind or grate them fine; I then put the substance into water, and I let it remain therein several hours; I then strain off the water, and I add fresh water in quantity sufficient to cover the substance. Which process I continue to repeat until the water pours off quite clear. Then I strain and press the water from the vegetable substance, which I then dry on a kiln, or other proper convenience. When the substance is quite dry I grind it in a corn or other proper mill until it becomes fine flour. Either of the above vegetables alone, or any two or more of them mixed together, and prepared as before specified, will answer for the purpose. The foregoing description is for the making course or common flour: when I make fine or best flour I pare or peel the rind off the vegetables before I grind or grate them. I then pursue the same process as with the coarse or common flour.

In witness whereof, &c.

Specification

Specification of the Patent granted to William-Henry Clayfield, *of Bristol, Wine-merchant; for certain Processes for separating the Alkalis of Potash and of Soda from their Sulphates or Vitriolic Salts, and from their Sulphurets or Combination with Sulphur, as in Soapers Black-ash and other similar Compounds.*

Dated November 22, 1804.

To all to whom these presents shall come, &c. Now know ye, that in compliance with the said proviso, I the said William-Henry Clayfield do hereby declare that my said invention is described in manner following; that is to say: In the first place I convert the sulphates or vitriolic salts into sulphurets or livers of sulphur by the common process, which is as follows. I introduce into a flat-bottomed reverberatory furnace, nearly resembling a lead furnace, or one of any other suitable construction, a quantity of sulphate of potash, sulphate of soda, or soapers black-ash, either severally and alone, or otherwise, by mixture of one or more of the said sulphates and black-ash, as may be most convenient or suitable to the intended purpose. And to the said substances, when in the furnace, I add a quantity of charcoal, wood, coal, peat, or other similar combustible matter, in small pieces, or coarse powder, and expose the mass to a red heat, to bring the salts into fusion. And I maintain and keep up the fusion, and frequently stir the mass, with the addition of more charcoal or inflammable matter, until the greater part of the sulphuric acid therein contained becomes converted into sulphur, and a large proportion of sulphuret is formed.

Having stated this process to be in common use, I cannot claim any exclusive privilege for the use of the same.

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The processes which are the object of my patent are as follow.

The sulphurets being formed from the salts as described above, and the matter still in a state of fusion, I add a still farther quantity of charcoal, or other combustible matter, to convert the mass into a paste; and at the same time I add a quantity of lead, in its metallic state, litharge, or other oxyde or calx of lead. Which metal or oxyde unites with the sulphur of the compound, forms an artificial galena, or sulphuret of lead, and leaves the alkalis united with a portion of carbonic acid formed from the coal and other inflammable substances made use of.

It is essentially necessary to the success of this decomposition, that the mass should be kept at a very low red heat, frequently raked about, with the addition of a farther quantity of charcoal, or other combustible matter, and intermixed with the lead or oxyde as intimately as possible. (To check the fusion of the mass more effectually, and to facilitate the combination of the lead with the sulphur, I occasionally make use of damp charcoal towards the end of the operation; I do not, however, consider this variation in the process absolutely necessary.)

The compound mass must then be withdrawn from the furnace, and frequently sprinkled with a small quantity of water, broke up, and exposed to the action of the atmosphere for a week or ten days; after which time the alkalis, being nearly saturated with carbonic acid, may be separated along with such other salts as may be present by lixiviating the mass, and the sulphuret of lead will remain behind.

The neutral salts may be separated from the above by crystallization; after which the alkalis may be obtained by

by boiling down the solution, or the soda may be first separated by a farther crystallization.

The proportion of ingredients will depend on the substances made use of. In those cases where the sulphates of potash or of soda are used in a dry state, about two-thirds the weight of charcoal, and about five parts of lead to four of the sulphate, will be required to effect the decomposition; but where soapers black-ash is made use of, a smaller quantity of the above materials will be sufficient.

Lastly, I employ zinc or its oxydes instead of lead or the oxydes of that metal, in the operations before described; but I give the preference to lead or its oxydes for their cheapness and facility of reduction.

In witness whereof, &c.

On the Treatment of Farm Horses.

By JOHN BANNISTER, *Esq.*

(Concluded from Page 186.)

FEW of the people whom I have now described, namely, those who break the bonds of every social tie to feed and pamper their favourite animals, will use the horses with cruelty, or neglect the management of them in the stable; but there are others of a different cast, who being by nature indolent, and of a morose and evil disposition, proceed to their work with disgust, and spend those hours, which should be appropriated to a necessary attendance on the horses, at the ale-house or the forge, or, in short, at any other place but where they are wanted. These often degenerate into the contrary extreme, and not only waste their master's property by neglecting his interest, but, careless of the welfare of the horses

horses with which they are entrusted, incapacitate them for business by their ill-usage and want of attention.

The possession of a fat team is likewise not unfrequently the master's pride; and when this happens to be the case, one can hardly blame the servant in any deception he may use to promote a sleek and comely appearance in his cattle, since by these arts he is likely to purchase his master's favour; and where a farmer is thus attached to the silly emulation of excelling his neighbours in this particular of a fat team, the allowance of corn, it may be presumed, is very ample, and the labour required from the horses by no means fatiguing.

The management of the plough-team varies essentially in different countries, and even in different parts of the same county; whether we consider the labour to be performed as a day's work by the same number of cattle, the quality and quantity of their food, or the stated hours for baiting and attendance. In the eastern part of Kent, the waggoner or head ploughman pays an early regard to his horses, and baits them continually with chaff and corn from the time of his rising at four o'clock till six or seven, when the day's work commences; and in the afternoon, whilst the mate is baiting, the waggoner employs himself by cutting cavin into chaff, or where this is not in sufficient plenty, hay and straw mixed, and sometimes oats in the sheaf. At eight in the evening he goes to bed, and leaves the attendance of the team to his mate, who sits with them till ten, so that the horses are left but a few hours to themselves; and this diligent attendance is unavoidably necessary, since in this country the horses are not permitted to have any rack-meat, but have generally a full allowance of corn; whereas, on the other side of the county, the stable door is rarely opened of a morning before five or six o'clock in the winter, and by

nine

nine in the evening the horses are racked up and left to their repose; and as by this method of giving the horses rack-meat, the less chaff is required, so there is generally a sufficient quantity of this produced by the thresher; if not, the labour of cutting does not often fall to the share of the ploughman, but is paid for by the farmer to a person who is expert at this business.

In support of the former practice may be urged the reserve of a considerable quantity of fodder, which, when given to the horses without limitation, forms a large item in the rural accounts at the end of the year, especially when the situation is within a small distance of London, or any place of considerable note where hay usually fetches a large price; to which may be added the advantage which the horses reap from the constant attendance that must necessarily be paid to them when baited in the manner before described, whereby the servants are kept continually in their work, and prevented from loitering away the afternoons at the ale-house or the smith's shop, as is too frequently the case with those who have more leisure on their hands; a great expense is likewise saved, which must otherwise be paid for cutting chaff. On the other hand, the farmer, who prefers the more general custom of allowing rack-meat to his horses, may enumerate the following advantages accruing from this method: First, the weekly allowance of corn may be more sparing, where the horses have constantly some kind of rack-meat to resort to, than when their whole dependence rests on the manger; nor is it necessary that such rack-meat be wholly confined to hay, but may consist partly of pea or bean straw, at those times when the labour of the horses is light; and in seed-time, or whenever the team is tasked with heavy work, though sainfoine, clover, &c. may be allowed them of a night, yet

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this need not be given to an unlimited degree, which indeed would quickly end in the consumption of a large stack, but be trussed out in such proportion as the master may judge expedient, obliging the servants to tend the horses with chaff in the afternoon. Under these restrictions, the consumption of fodder may perhaps not exceed in value the sheaf-corn allowed to the teams in East Kent. A second consideration in favour of this practice is in having the ploughman at leisure in the afternoon to employ about occasional jobs, whilst in East Kent these domestics have a just excuse for refusing to lend a helping hand towards expediting any other work than what appertains solely to the management of their horses: and this advantage of having the servants at liberty to employ in the afternoon is of no inconsiderable moment, since by their efforts many jobs may be accomplished which would otherwise have demanded the aid of a labourer, the expenses of whose hire in the course of a winter will swell up to a large amount; not but there are many farmers who never employ their servants in an afternoon to any other work than what the care of the horses affords them; and this relaxation on the part of the master has given so great encouragement to the servants in their obstinacy, as to furnish a pretext for disobeying every order but what respects the horses, or the work to be done by them; a disposition which there seems no other means of correcting but through the medium of that necessary officer of justice, a civil magistrate, who never fails on application to back the master's intreaties with a threat of Bridewell, in case of the servant's obstinacy and refusal, a measure which generally secures their compliance.

To the two considerations last mentioned may be subjoined a third, which in the end may turn out of more

consequence

consequence than either of the former, and that is the opportunity enjoyed by the farmer who gives his horses rack-meat, of seeing the stable-door locked up at night and opened again in the morning; and this cannot be so conveniently done where the ploughman is to sit up late, and to rise the next morning at three or four o'clock, and thus an object of the most serious consideration is left to the care of fellows, who are rarely deserving of any trust; namely, the danger from fire, whereby the negligence of the servant may involve a family in total ruin, not to mention the great waste of candles in the many dark hours wherein the ploughman is necessarily engaged with his horses.

Such are the different modes of conducting the economy of a farmer's stable throughout the winter months; where, without the most vigilant caution on the part of the master, such waste will be committed as to render fruitless and abortive his most laborious exertions in the field.

Whichever of these methods shall be preferred, it is obvious that the maintenance of the horses in a condition to go through their winter's labour will be attended with no trifling expense; and therefore it should seem a matter of prudence to be furnished with green meat early in the spring, that the teams being turned into the field, or having a sufficient quantity of grass mown for them, the expense of corn may in a great measure be saved: for so highly nutritious are the juices of green food of every kind, and so agreeable is this provender to the taste of these animals, they will go through more severe labour, carry a smoother coat, and thrive abundantly faster on this meat alone than with a full allowance of hay and corn; so that there are many farmers who never give their horses corn during the summer months, whilst

others take off half their winter's allowance. This is a great saving, besides the advantage of employing the ploughmen in the latter part of the day at various kinds of business, which, as the spring advances, becomes necessary to be expedited.

The most general food for working-horses in the first part of the summer, when not turned to grass, is that arising from the tare. This succulent herbage is raised from the small seed called winter tare, which ought to be sown with all convenient dispatch after harvest, on a piece of ground in good condition, and at no great distance from the yard: much depends on the nature of the soil and the state of the weather during the winter and spring months, as to the season when these pulse will produce a crop fit for the scythe; but if the weather has not been very unkindly, they may be expected to turn out a tolerable good swarth at the beginning of old May, and when this first provision shall be expended, the clover and sping tares will come in, so as to afford the horses a constant succession of green meat during the summer. And this method of feeding them with green meat in the stable or in the yard, (for there are many people who contend in behalf of the superior advantage in the point of health, when the horses are turned into the yard of a night, and there fed from the crib, over the mode of keeping them continually in the stable,) the practice, I say, of confining them to their meat is far preferable to that of turning the horses into a meadow when their day's work is finished, and this on many accounts: First, by having their meat cut for them, they avoid the continual plague of those tormenting insects, flies, which are a perpetual source of complaint to cattle of every kind when feeding abroad in the summer months. Secondly, by thus feeding and reposing themselves

selves at home, the mischief likely to accrue from the horses breaking out of their pastures is obviated: whereas when they are turned into the uplands, although the grass be never so good, the gates well secured, and the fences strong; yet so tempting is the verdure of every field at this season of the year, and the horse an animal so prone to ramble, that the danger of their quitting the pasture allotted them during the night is very great; and in such case a team of horses may create more mischief in six hours than 20*l.* or perhaps 50*l.* will repay, besides the plague of seeking them in the morning, the greatest part of which may haply be consumed in a fruitless enquiry, and half the day be gone past ere the teams are harnessed for their work. Thirdly, the waste which is made either in a piece of grass or clover where the horses are suffered to ramble over the whole close *ad libitum*; it being a clear case, that the produce of one acre of green meat given in the rack will maintain the same number of horses much longer than three acres would have done if they had been suffered to go over the field at their pleasure. Add to these another consideration, which to a farmer is a matter of the utmost importance; and this is, the waste of the dung and urine; since it is universally allowed, that the soil of the horse dropped casually in various parts of the field is of little or no use, the virtues of it being exhausted by the heat of the sun, and the surface of the ground prevented by this covering from putting forth a fresh shoot of grass, whereas when the team is fed with green meat in the stable, with a plentiful allowance of litter, the dunghill will be considerably raised during the summer; for this food, being very succulent, acts with the animal as a powerful diuretic, by which means the straw is quickly converted into manure, and becomes a valuable addition

to the repository of a farm-yard. I know but of one argument which the advocates for grazing their horses abroad can bring in favour of this practice; namely, the keeping the animals in health by action, to which they are naturally inclined, and thus preventing the accidents of swelled heels, &c. But this advantage is by no means precluded, when the mode of feeding the team with green meat in cribs is pursued, as hath been touched upon before; and here they may have the free enjoyment of their limbs, without any of those hazards so likely to ensue from their feeding abroad; though when a horse is kept with proper strictness to his work, I believe there will be little danger of his becoming greasy by standing in the stable at night, except in some particular constitutions.

Though tares are a very wholesome diet in the first part of the summer, they should be cautiously given, or rather wholly discontinued as the summer advances, and they are become rotten on the ground. At this time I am convinced they are a food highly improper for the horses, and when given in that state frequently turn out very prejudicial to their health; for this vegetable, from its extreme succulency, contributes to fill their bodies with ill humours, whence originate disorders of various kinds, such as yellows, staggers, farcy, and other fatal or incurable maladies. On this subject I can speak with the greater confidence, as the major part of my own team fell a sacrifice to this imprudent conduct in the year 1773. In this summer several of my working-horses were carried off by the staggers, occasioned, as I am well persuaded, by their feeding in the month of June on summer tares, which were remarkably gross, and by being lodged had become rotten on the ground. To avoid this pernicious consequence, it seems the best method to discon-

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tinue the use of tares as soon as the clovers become fit for the scythe, and where there remains no other alternative, rather to turn the team abroad, than to endanger their healths by suffering them to feed on such foul and unwholesome diet.

But to guard effectually against every obstacle, the most prudent way is to raise a field of lucerne in the vicinity of the yard, which will afford a plentiful supply of whosesome and nutritious aliment till the time approaches for taking the horses up to dry meat. The first cutting of this excellent vegetable, if properly managed, may commence a fortnight or three weeks before the tares will be ready for the scythe, and the mowing may be continued throughout the summer without any danger to the cattle, and to the infinite emolument of the farmer, who will thus possess an opportunity of furnishing his horses with a wholesome food, and that in great abundance, and at a trifling expense, till the return of winter renders it necessary to discontinue the green meat, and the tares and clovers may be reserved for the other various purposes to which they are capable of being applied.

It is a very salutary practice to bleed the team previous to turning the horses to grass in the spring, and to repeat it when they are taken up to dry meat at the autumn, though there are many people who object to these periodical evacuations, alledging that the constitution of the animal is rather injured than otherwise by this habit. But when it is recollected that the horse is subject to a greater variety of disorders than any other quadruped, and from his constant labour is particularly liable to have his blood and juices contaminated, it must be evident that this disposition is likely to be increased by a change of diet, particularly on a sudden transition from dry fodder to green meat, where from the superabundant succu-

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lency of the food, the humours, which at this season of the year are in continual flux and agitation, will be accelerated to that degree as to bring on disorders which may terminate in the death of the creature, and which might not in all probability have taken place, if a copious discharge of blood had been promoted some few days before the winter provender had been discontinued; nor is the autumnal bleeding less necessary to carry off any foul humours which the succulency of the grass may have occasioned, and to preserve the health of the team during the winter; and if to this bleeding a dose or two of physic were to be added, it would be a still farther means of insuring the health of the horses, and rendering the farrier's attendance unnecessary.

The proper time for taking the horses from grass is about Michaelmas; for, though we have often warm sunny weather till the latter end of October, yet the grass by that time will have lost much of its sweetness, and become less nutritious.

One acre of whole ground is accounted a good day's work for a plough and four horses, if the soil is of a middling texture; but in stirring fallows, when the days are long, and the land pulverized by the former tillage, on very light soils, an acre and a half may, with great facility, be ploughed in a day by a four-horse team.

On stiff lands it will be necessary to unite an additional pair of horses to the team, and this renders the expense in tillage on these grounds much more considerable than on the lighter soils; but this increase of charge will be amply compensated by the future crop, which never fails to be more abundant and productive than what is raised on the thin grounds.

The term for the mares going with foal is eleven months, with the addition of a day to every year of the animals

animal's age. The mare which is intended to supply the team with draught colts should be large-limbed, close-jointed, short-necked, wide-chested, home-ribbed, with a capacious body; her eyes should be clear, full, and pellucid, and her nostrils large and open; in disposition she ought to be gentle and tractable, of a constitution healthy and vigorous, free from any blemishes, either hereditary or acquired. The horse should be bold and spirited, well made, and of a kindly disposition; his constitution should be strong, his temper good, and, in short, neither in mind or body, ought he to be contaminated with vices or disease of any kind, since on the good qualities and strength of constitution in the sire and the dam depends in a great measure the future welfare of the colt. The proper time for putting the mare to horse is in the months of May or June, according to the fertility of the soil, always observing that an early colt is to be preferred to one which falls later in the season.

During the time of gestation, the mare may work in the team as usual, till within a fortnight of the time when she is expected to foal; but it is necessary that her labour as she advances in her pregnancy should be gradually slackened, lest any hurt should accrue to the foal or the dam by hard exertions in the harness, which might probably occasion the mare to slink her foal, or perhaps might be productive of still more dangerous consequences. The mare, within ten days or a fortnight of the time when she is expected to foal, should be turned into an orchard or other warm inclosure, where she may rest secure from the interruption of other horses, and be free from any annoyances likely to occasion disturbance to her at this time, and after foaling should be allowed to

run

run with her colt in the same pasture for a month or longer, if not particularly required in the team. The field set apart for the dam and colt should be free from declivities or precipices of any kind, and the grass should be of a length to afford a good bite, and to furnish sufficient nourishment to the mare for a copious supply of milk.

During the time that the colt runs with the dam it ought never to be allowed to suck whilst the mare is warm from the consequence of her labour, as the milk at that time would be highly prejudicial to the young creature.

The proper time for removing the colt from the dam is about Michaelmas; and at this time care should be taken to keep the mare and foal from the hearing of each other, that neither the mare may bewail the loss of her colt, nor the latter fret and pine after its mother. The best method will be to confine the foal in a small stable by himself, which should be furnished with a rack and manger, where he may be fed with well-shaken hay and clean-sifted oats, bruised a little in a mill. With this management he will quickly forget his dam, and become gentle and familiarized to his keeper, and in fair weather may be suffered to exercise himself in a pasture adjoining to the stable, but this should be only for a little while in the middle part of a sunny day, the tenderness of the young animal rendering it necessary that he should be kept under cover during the winter.

Having been thus properly managed in the first winter, he will by the following spring have made rapid advances in growth, and as the warm weather comes on may be suffered to range throughout the day in his pasture, and at night be lodged in the stable, and when on the

the approach of summer it will be no longer necessary to bring him into the house, he may continue in the pasture as well during the night season as in the day.

The proper age for gelding the colts is at ten days or a fortnight old, or as soon as the stones are come down, and the most proper season is the months of April or May, and if not done at that time it ought to be deferred till the end of September. Although it be safest to cut the foal at the age above mentioned, yet the operation may be performed without hazard at two years old.

The like care in respect to housing the colt is required in the second winter, as was directed in the first, only that now he may be led by the halter to the pond, be frequently curried, and accustomed to such other acts of familiarity which have a tendency towards rendering him tractable and obedient, so that at the return of summer his harness may be put on, and he may be employed in some kind of gentle draught work in company with other horses; but this exercise should at first be very light and easy, and not protracted too long, so that the young horse may seem rather pleased than disgusted with his new employment. He should often go short journies in the team upon the road, that his sight may be early inured to different objects, which will dispose him to be more tractable and less addicted to fear than he would have been if this precaution were neglected. By this management, and by alternate easy days work at plough and in the waggon, the young horse at the end of the summer will become able to perform nearly an equal share of labour with the rest of the team, and having been fed and managed in the like manner with the other horses, may, at the approach of winter, be taken into the stable with them.

The docking of colts may be performed when they are a twelvemonth old, either in the spring or autumn, but it ought never to be done in the summer months.

Those people who have great store of waste pasture, such as heaths, moors, &c. possess the fairest opportunity of breeding colts, which are here reared at a trifling expense, and having plenty of room to sport and range at pleasure, with good and wholesome water, do grow out to their full size, and become more serviceable for the team than those which, from a more confined situation, have not enjoyed these advantages.

Analytical Experiments and Observations on Lac.

By CHARLES HATCHETT, *Esq. F.R.S.*

From the PHILOSOPHICAL TRANSACTIONS of the ROYAL SOCIETY.

THE period is uncertain when the substance called lac, so curious in its origin and so useful to many arts, was first introduced into Europe; and, although it probably was known to the ancients, yet the inaccuracy of their descriptions precludes this from being stated as a positive fact.

The natives of India have long employed it for various purposes, exclusive of those which cause it to be in request with Europeans; but many of the Indian processes are undoubtedly as yet unknown to us.

One of these, of a very useful nature, was some time since obligingly communicated to me by Charles Wilkins, Esq. F. R. S. and has been the cause of this inquiry into the nature and properties of lac.

Mr. Wilkins informed me, that the Hindûs dissolve shell lac in water, by the mere addition of a little borax; and

and the solution, being then mixed with ivory-black, or lamp-black, is employed by them as an ink, which when dry is not easily acted upon by damp or water. Upon trial I found the fact to be exactly as Mr. Wilkins had stated, and therefore made other experiments; but the results of these I shall at present omit, as they will occur with more propriety and perspicuity in the latter part of this paper.

In respect to the natural history of lac, we are much indebted to Mr. Kerr *, Mr. Saunders †, and Dr. Roxburgh ‡; from whose valuable communications to this Society, we learn many curious particulars concerning the formation of this substance, which, from their accounts, and from inspection, evidently appears to be the nidus or comb of the insect called coccus or chermes lacca, deposited on branches of certain species of mimosa and other plants.

Lac is distinguished into four kinds; of which, however, only three are commonly known in commerce, *viz.* stick lac, seed lac, and shell lac; the difference of these, with that of the fourth, called lump lac, is as follows.

1. Stick lac is the substance or comb in its natural state, incrusting small branches or twigs.

2. Seed lac is said to be only the above, which has been separated from the twigs, and reduced into small fragments; but I suspect it to have undergone some other

* Natural History of the Insect which produces the Gum Lacca. By Mr. James Kerr, of Patna. Phil. Trans. for 1781, p. 374.

† Some Account of the vegetable and mineral Productions of Boutan and Thibet. By Mr. Robert Saunders. Phil. Trans. for 1789, p. 107.

‡ *Chermes Lacca.* By William Roxburgh, M. D. Phil. Trans. for 1791, p. 228.

 process,

process, as I have found the best specimens to be very considerably deprived of the colouring matter *.

3. Lump lac is formed from seed lac, liquefied by fire, and formed into cakes. And,

4. Shell lac, according to Mr. Kerr and Mr. Saunders, is prepared from the cells, liquefied, strained, and formed into thin transparent laminæ, in the following manner.

"Separate the cells from the branches; break them "into small pieces; throw them into a tub of water, for "one day; wash off the red water; dry the cells, and with "them fill a cylindrical tube of cotton cloth, two feet "long, and one or two inches in diameter; tie both "ends, and turn the bag above a charcoal fire; as the "lac liquefies, twist the bag, and, when a sufficient "quantity has transuded the pores of the cloth, lay it "upon a smooth junk of the plantain tree, and with a "strip of the plaintain leaf draw it into a thin lamella; "take it off while flexible, for in a minute it will be hard "and brittle †."

The degree of pressure on the plantain tree regulates (according to Mr. Saunders) the thickness of the shell; and the quality of the bag determines its fineness and transparency.

Assam furnishes the greatest quantity of the whole of the lac now in use ‡.

* Mr. Wilkins informs me that the crude lac, as it is taken from the branches and twigs of the trees, is usually deprived of its colouring matter by boiling, having been previously reduced, by pounding, into small fragments. In Bengal, the silk dyers are the people who thus produce what we call the seed lac, which they do for the sake of the colour.

† Phil. Trans. 1781, p. 378.

‡ Phil. Trans. 1789, p. 109.

Mr.

Mr. Kerr (speaking of stick lac) observes, that the best lac is of a deep red colour; for, if it is pale and pierced at the top, the value is diminished, because the insects have left their cells, and consequently these can be of no use as a dye or colour, but probably may be better for varnishes.

The seed lac which I have examined contained but little of the colouring matter, and appeared (as I have already observed) to have undergone some process of purification; but, of all the varieties, shell lac contains the least of the tinging substance, as may well be expected, when the mode of preparing it is considered.

It is remarkable, that although lac has been known, and imported into Europe, during so long a time that the date cannot now be ascertained, yet it has but little attracted the attention of chemists.

The first chemist of eminence who mentions it, and the only one who has subjected it to any thing like a regular examination, is the younger Geoffroy, whose paper is published in the *Mém de l'Acad. de Paris* for the year 1714 *. In this paper Mr. Geoffroy seems to have been chiefly induced to examine it on account of its tinging substance; but he nevertheless has not neglected the substance which constitutes the cells. This he considers to be a sort of wax, very distinct from the nature of gum or resin. But it is to be observed, that he formed this opinion not so much upon the results of chemical experiments, as upon the cellular construction observed in the stick lac, which, as he justly remarks, demonstrates it to be formed by insects, after the manner that the honeycomb is formed by bees; and that it is not therefore,

* Observations sur la Gomme Lacque, et sur les autres Matières animales qui fournissent la Teinture de Pourpre. Par M. Geoffroy le jeune. *Mém. de l'Acad.* 1714, p. 121.

fore, as some have supposed, a gum or resin, which has exuded from vegetables simply punctured by insects *.

Geoffroy and Lemery obtained from lac, by distillation, some acid liquor, and a butyraceous substance. Moreover, Geoffroy observes, that, when stick lac was thus treated, some ammonia was also obtained, but not when seed lac was employed.

He also mentions another sort of lac, brought from Madagascar, and called by the natives *Lit-in-bitsic.* This substance, he says, is scarcely to be distinguished from bees-wax, which it much resembles in colour and odour; and that it is produced by a grayish insect, much larger than the chermes lacca. It is evident however, from Geoffroy's description, that this substance is very different from the common lac; and there can be little doubt, but that it is the same as that which was, a few years ago, examined by Dr. Pearson, under the name of white lac, a substance resembling the Pé-la of the Chinese †.

Geoffroy (as I have stated) considered lac as a sort of wax; and since his time it has scarcely, if at all, been subjected to chemical examination; it is not therefore suprising, that the opinions of chemists concerning it have been various. Chaptal adopts the opinion of Geoffroy, and calls it a kind of wax ‡; but Gren § and Fourcroy ‖ regard it as a true resin.

* Mr. Kerr observes, that as a red substance is obtained by incision from the plaso tree, very analogous to lac, it is probable that the insects have little trouble in animalizing the sap of these trees in the formation of their cells. Phil. Trans. 1781, p. 377.

† Phil. Trans. 1794, p. 383.

‡ Chaptal's Elements; English edition, vol. III. p. 387.

§ Principles of modern Chemistry, vol. I. p 388.

‖ *Systéme des Connoissances chimiques.* Tome V. p. 264.

§ I.

§ I. *Effects of different Menstrua on the Varieties of Lac.*

1. When water is poured on stick lac, which has been separated from the vegetable branches, and reduced to a coarse powder, it immediately begins to be tinged with red; and, with the assistance of heat, a deep-coloured crimson solution is formed.

Repeated operations of this kind reduce stick lack to a yellowish-brown substance; and the water no longer receives any colour.

The portion thus separated from stick lac has, upon an average, amounted in my experiments to about 10 *per cent.* but this is not to be regarded as the total quantity, for a part is obstinately retained by the resin and other ingredients, so that it cannot be completely separated; and, moreover, very considerable variations must be expected in different samples.

Fine seed lac did not afford more than 2½ or 3 *per cent.* of the colouring substance; and shell lac, when treated in the same manner, (*i. e.* merely with water,) did not yield more than ½ *per cent.*

2. Alcohol dissolves a considerable portion of each of the different kinds of lac; and, when heat is not employed, the dissolved part is resin, combined with some of the colouring matter; but, if the lac is digested with heated alcohol, then the solution is more or less turbid, in consequence of some of the other ingredients becoming mixed and suspended; so that it is afterwards extremely difficult to obtain it in a state of purity and transparency, either by repose or by filtration.

The resin may be obtained by immediately subjecting the solution to evaporation or distillation, or by previously pouring it into water with which a small quantity of muriatic or acetic acid has been mixed; for thus, when the

the whole is heated, a curdy precipitate of resin is formed, and may be separated by a filter, after which the liquor may be evaporated, in order to obtain any resin, or other substance, which may remain in solution after the first operation.

The solution formed by digesting stick lac in alcolol, without heat, is of a dark brownish-red colour, and the insoluble part subsides in the state of a dark-coloured magma; this retains the greater part of the colouring matter, which, as I have already observed, is most easily soluble in water.

The proportion of resin thus dissolved, when stic lac is treated with alcohol, has, in my experiments, amounted to 67 or 68 *per cent.* but this must depend on the quality of the samples.

The seed lac which I examined was very pure, and yielded to alcohol about 88 *per cent.* of resin: it contained but little of the colouring matter; and the other substances subsided, and formed a cloud at the bottom of the glass vessel.

Shell lac in small fragments, by simple digestion with alcohol, afforded in the first instance nearly 81 *per cent.* Part of the resin, however, still remained mixed with the residuum, and could not be separated but by subsequent operations: this part amounted to about 10; so that the total quantity of resin, in the shell lac which I employed, may be estimated at 91 *per cent.*

When the shell lac was only reduced into small fragments, these (after the separation of the first portion of resin) retained their figure, but were become more bulky, very elastic, and nearly white. I at first, therefore, suspected, that some caoutchouc was present in lac; but, finding that boiling water destroyed this elasticity, I was induced to make subsequent experiments, by which I discovered,

discovered, that the elasticity of this residuum was principally owing to a substance which appeared to possess the properties of vegetable gluten. This, however, I shall more fully notice in another part of the paper.

The resin obtained from the varieties of lac is brownish yellow, and is not so brittle as the generality of other resinous substances.

3. Sulphuric ether does not seem to act so powerfully upon the varieties of lac as alcohol; for, as a great part of the resin is protected by the colouring matter, and by the other ingredients which are insoluble in ether, it naturally follows, that less of it can be separated by this liquor than by alcohol.

The different kinds of lac which have been digested in ether are considerably softened, although in other respects very little alteration is produced. Ether, therefore, is not the best menstruum for lac; but, under certain circumstances, it may be occasionally employed with advantage, for the purpose of analysis.

4. Concentrated sulphuric acid acts in the first instance on the colouring matter of lac; but, after a short digestion in a sand bath, the whole is converted into a reddish-brown thick liquor, which soon becomes black; and the chief part of the lac is separated in an insoluble state, resembling coal.

During the solution of lac in sulphuric acid a considerable quantity of sulphureous acid gas is evolved.

5. When lac is digested with nitric acid, nitrous gas is at first produced; the lac swells much, and is converted into a deep yellow opaque brittle substance, which, by a sufficiency of nitric acid, and continuation of the digestion during about forty-eight hours, is dissolved.

The solution however is turbid, and, when poured into a large quantity of distilled water, deposits some yellowish

lowish flocculi, which, being collected, are found to be a sort of wax.

The filtrated liquor is of a bright golden yellow; and, when saturated by ammonia, changes to orange colour, but does not yield any precipitate, nor any traces of oxalic or malic acid.

This yellow nitric solution is converted, by evaporation, into a deep yellow substance, which burns like resin, but is soluble in boiling water.

The alkalis and lime, being added to this aqueous solution, do not produce any precipitate, but the yellow colour is very considerably deepened; and by evaporation an orange-coloured substance is obtained, which is still easily soluble in water, and consists of the deep yellow substance above mentioned, combined with the alkali or lime.

6. Muriatic acid dissolves the colouring matter and gluten of lac; but its action on these is feeble, unless the resin has been previously separated.

7. Acetous acid, in its effects, much resembles muriatic acid.

8. Stick lac, seed lac, and shell lac, are partially dissolved by acetic acid; and, if this be heated, a considerable portion is taken up.

The dissolved part consists of the colouring extract, of resin, and of gluten; the wax being the only ingredient which is insoluble in this menstruum; but a portion of the former substances, being enveloped by the wax, are protected from the action of the acetic acid.

The acetic solution of lac becomes turbid when cold, and deposits part of the resin; a portion however remains in solution, and may be precipitated by water; after which, the liquor retains some gluten and colouring extract,

tract, which may be precipitated by saturating the acid with an alkali, and by subsequent boiling.

For the reasons above stated, it would be difficult to effect a complete solution of lac by means of acetic acid; but this may nevertheless be advantageously employed in analytical operations, when alternately used with alcohol.

9. A saturated solution of boracic acid in water dissolves the colouring extract; but, as the effect does not surpass that of water alone, we may conclude that lac is little, if at all, acted upon by boracic acid.

10. It has been already stated, that sub-borate of soda or borax has a powerful effect on lac, so as to render it soluble in water; and, as the preceding experiments prove that boracic acid alone scarcely acts upon lac, there is every reason to believe, that the excess of soda present in borax is the active substance; and this conclusion will be confirmed by the results of subsequent experiments made with the alkalis.

In order to render lac (especially shell lac) soluble in water, about $\frac{1}{5}$ of borax is necessary; and this may be previously dissolved in the water, or may be mixed and added together with the lac.

The best proportion of water to that of lac is 18 or 20 to 1. So that 20 grs of borax, and four ounces of water, are, upon an average, requisite to dissolve 100 grs. of shell lac; but more water may be occasionally added, to supply the loss caused by evaporation during the digestion, which should be made nearly in a boiling heat.

This solution of shell lac is turbid, and of a reddish-brown colour; when considerably diluted with water, and agitated, a weak lather is formed; it is decomposed by acids, and the lac is precipitated in yellow flocculi, which do not apparently differ from the lac originally employed.

The general properties of the solution show that it is a saponaceous compound, which, being used as a varnish or vehicle for colours, becomes (when dry) difficultly soluble in water, although this was the liquid employed to form the solution.

A white thick scum or cream collects on the surface of this liquid, after it has been suffered to remain tranquil for some time, and is found to be produced by a sort of wax, which I shall more particularly notice when the analyses of the varieties of lac are described: but, in the present case, this wax appeared in some degree to be converted into an almost insoluble soap by the alkali of the borax, and may be regarded as the principal cause of the turbidness of the solution.

11. The lixivia of pure soda and of carbonate of soda completely dissolve the different kinds of lac; and these solutions exactly resemble those formed by means of borax, excepting that they are deeper coloured.

Rather less than $\frac{1}{5}$ of carbonate of soda is required to dissolve shell lac; and this solution, when dried, is sooner affected by damp or water than the solution prepared by borax.

12. Lixivium of pure or caustic potash speedily dissolves the varieties of lac, and forms saponaceous solutions, similar to that in which borax was employed, exclusive of the colour, which is deeper, and more approaching to purple.

Lixivium of carbonate of potash extracts a great part of the colouring matter, but does not form so complete a solution of the entire substance of lac, as when pure potash is employed.

The above alkaline solutions, by repose, afford the waxen soap which has been mentioned; and acids, being added to these solutions, and to that formed by borax,

borax, precipitate the lac in a flocculent state, and of a yellow or buff colour; which precipitate, when melted, becomes similar to the lac originally employed. If, however, an alkaline solution of shell lac (prepared, for instance, with soda) be gradually dropped into a sufficient quantity of muriatic acid diluted with an equal portion of water, and nearly heated to the boiling point, and if after boiling the whole for about one hour the coagulum be separated, and the clear liquor be carefully saturated with soda, and again made to boil, a small quantity of a flocculent precipitate is obtained, which was found to be analogous to precipitated vegetable gluten, combined with some of the colouring extract.

13. Pure ammonia, and carbonate of ammonia, readily act upon the colouring matter of lac, but do not completely dissolve the entire substance.

TO BE CONCLUDED IN OUR NEXT.

Observations on Basalt, and on the Transition from the vitreous to the stony Texture, which occurs in the gradual Refrigeration of melted Basalt; with some Geological Remarks. In a Letter from Gregory Watt, *Esq. to the Right Honourable* Charles Greville, *V. P. R. S.*

From the Philosophical Transactions of the Royal Society.

THE important geological consequences that seem deducible from the changes of texture developed by Sir James Hall's very judicious experiments on the regulated cooling of melted basalt, induced me to attempt a repetition of them, some time after the publication of his interesting

interesting and ingenious Paper *. I believe that formerly I had the honour of showing you some of the results of my imperfect and diminutive experiments, which only served to afford additional proofs of the transition from the vitreous to the stony texture, which takes place in the gradual refrigeration of glass. Circumstances have prevented my resuming these investigations, till it lately occurred to me that something might be learned, by exposing to the action of heat a much larger mass of basaltic matter than, as far as I am informed, had ever at one time been subjected to experiment.

One of the common reverberatory furnaces used in iron founderies for the fusion of pig iron, was strongly heated by a fire maintained for several hours. About seven hundred weight of amorphous basalt, here called Rowley Rag, was broken into small pieces, and deposited gradually on the elevated part of the interior of the furnace, between the fire and the chimney, from whence, as it melted, it flowed into the deeper part, in which, in ordinary operations, the melted iron is collected. It was observed by the persons attending, that it did not require half the quantity of fuel, to fuse the basalt, that would have been necessary to melt an equal weight of pig iron. When the whole was melted, it formed a liquid glass, rather tenacious, from which a large ladle-full was taken, which, on being allowed to cool, retained the characters of perfect glass. The fire was maintained, though with gradual diminution, for more than six hours; after which time, the draught of the chimney was intercepted, the surface of the glass was covered with heated sand, and

* Published in the Transactions of the Royal Society of Edinburgh, Vol. V.

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the furnace was filled with coals, which were consumed very slowly. It was eight days before the mass in the furnace was sufficiently cool to be extracted, and even then it retained considerable internal heat.

The form of the mass, being given by the bottom of the furnace, was considerably irregular, approaching to the shape of a wedge whose lower angles were rounded. It was nearly three feet and a half long, two feet and a half wide, about four inches thick at one end, and above eighteen inches at the other. From this diversity of thickness, and from the unequal action of the heat of the furnace, too great an irregularity had prevailed in the refrigeration of the glass, to permit its attainment of a homogeneous texture. These circumstances might probably have been counteracted by better devised precautions; but the inequality of the product is not to be regretted, since it has fortuitously disclosed some very singular peculiarities, in the arrangement of bodies passing from a vitreous to a stony state, which might have remained unobserved, if the desired homogeneity of the result had been obtained. I shall now endeavour to describe the various products of this operation; and I shall also submit to your consideration, some remarks which appear to me to arise naturally from the phenomena I have observed; premising that, except where my opinions are supported by the unequivocal demonstration of facts, I offer them with the utmost deference to the decision of more experienced and judicious mineralogists and geologists.

It may be proper to give a concise description of Rowley rag itself, before I consider the products which it yields by igneous fusion. This species of basalt is fine-grained, of a confused crystallized texture; its fracture uneven in small pieces, conchoidal in large pieces. Its hardness

hardness superior to common glass, but inferior to feldspar. Its tenacity considerable. Its action on the magnetic needle strong, but without signs of polarity. Its specific gravity, according to my trials, 2.868. Its general colour iron gray, approaching to black. It is opaque; and it reflects light from a number of brilliant points, some of which seem to be feldspar, and others hornblende *.

1st. This substance is easily fused into glass, whose texture is completely vitreous, with few air-bubbles. Its fracture undulated conchoidal. Its hardness superior to feldspar, but inferior to quartz. It possesses scarcely any action on the magnetic needle. Its colour is black: it is nearly opaque, being translucent only in very thin fragments. Its specific gravity appears to be 2.743.

2d. The tendency towards arrangement, in the particles of the fluid glass, is first developed by the forma-

* "The ragstone has been accurately analysed by Dr. Withering, "who found that 1000 parts of it contained 475 parts of siliceous "earth, 325 argillaceous earth, and 200 calx of iron; but this iron "seems to me to be in a very small degree of calcination, from the "dark blue colour of the stone, from the rusty colour it assumes on "being exposed to a farther state of calcination by air and water, and "from the magnetic property of the mountains, which, as Dr. Plot "observed, turned the needle 6° from its proper direction. This mag- "netic property has since been observed in several basaltic mountains, "particularly in the Giant's Causeway in Ireland, and very remark- "ably in a basaltic columnar mountain called Compass Hill, in the "island Cannay, one of the Hebrides, described by George Demp- "ster, Esq. in the Transactions of the Society of Antiquaries in "Scotland, Vol. I." See Mineralogy of the South-west part of Staffordshire, by James Keir, Esq. F. R. S. published in Shaw's History of Staffordshire, Vol. I.

Mr. Kirwan states the specific gravity of Rowley rag, which he calls *ferrilite*, at 2.748; and assigns its melting point at 98° of Wedgwood's pyrometer.

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tion of minute globules, which are generally nearly spherical, but sometimes elongated, and which are thickly disseminated through the mass. The colour of these globules is considerably lighter than that of the glass; they are commonly grayish-brown, sometimes inclining to chocolate brown, and, when they have been formed near the interior surface of the cavities in the glass, they project, and resemble a cluster of small seeds. Their diameter rarely exceeds a line, and seldom attains that size, as, in general, they are so near to one another, that their surfaces touch before they can acquire considerable magnitude. In the process of cooling, they adapt their form to their confined situation, fill up every interstice, and finally present a homogeneous body, wholly unlike glass, and equally unlike the parent basalt. When the union of the little globules has been imperfectly effected, the fracture of the mass indicates its structure, by numerous minute conchoidal fractures, which display the form of each globule. But, if the arrangement has extended a little farther, all these subdivisions are entirely lost; the mass becomes perfectly compact, has an even or a flat conchoidal fracture, is nearly of the same hardness as the glass, is commonly of a chocolate colour, graduating into a brownish-black, and the intensity of the colour increases in proportion to the degree to which the arrangement has extended. Its aspect is rather greasy; and it much resembles some varieties of jasper, in the compactness of its texture, and in its opacity. Its magnetic action is extremely feeble. Its specific gravity appears to be 2.938.

3d. If the mass were now rapidly cooled, it is obvious that the result would be the substance I have just described; but, if the temperature adapted to the farther arrangement of its particles be continued, another

 change

change is immediately commenced, by the progress of which it acquires a more stony texture, much greater tenacity, and its colour deepens as these changes advance, till it becomes absolutely black. Sometimes this alteration is effected by a gradual transition, the limits of which cannot be assigned, but more generally by the formation of secondary spheroids, in the heart of the compact jaspideous substance. These spheroids differ essentially from those first described; the centres of their formation are more remote from each other, and their magnitude is proportionably greater, sometimes extending to a diameter of two inches, and seeming only to be limited by contact with the peripheries of other spheroids. They are radiated, with distinct fibres; sometimes the fibres resemble those of brown hæmatites, and sometimes they are fasciculated irregularly, so as to be very similar in appearance to the argillaceous iron ores rendered prismatic by torrefaction. They are generally well defined, and easily separable from the mass they are engaged in; and often the fibres divide at equal distances from the centre, so as to detach portions of the spheroid in concentric coats. The transverse fracture of the fibres is compact and fine grained; the colour black; and the hardness somewhat inferior to that of the basaltic glass. When two of the spheriods come into contact by mutual enlargement, no intermixture of their fibres seems to take place; they appear equally impenetrable, and, as neither can penetrate, both are compressed, and their limits are defined by a plane, at which a separation readily takes place, and each of the sides is invested with a rusty colour. When several spheroids come in contact on the same level, they are formed by mutual pressure into pretty regular prisms, whose division is perfectly defined; and, when a spheroid

spheroid is surrounded on all sides by others, it is compressed into an irregular polyhedron.

4th. The transition from this fibrous state to a different arrangement, seems to be very rapid; for the centre of most of the spheroids becomes compact, before they attain the diameter of half an inch. As the fibrous structure propagates itself by radiating into the unarranged mass, the compact nucleus which supplies its place gradually extends, till it finally attains the limits of the spheroids; and the same arrangement pervades the matter comprehended between them. The mass has now assumed a compact stony texture, and possesses great tenacity. Its hardness is somewhat inferior to that of the glass from which it was formed. Its action on the magnetic needle is very considerable. Its specific gravity is 2.938. Its colour is black, inclining to steel gray: it is absolutely opaque, and only reflects light from a few minute points. Though the divisions between the spheriods are rendered imperceptible to the eye, they are not obliterated, and their rusty surfaces are often disclosed by an attempt to fracture the mass.

5th. A continuation of the temperature favourable to arrangement, speedily induces another change. The texture of the mass becomes more granular, its colour rather more gray, and the brilliant points larger and more numerous: nor is it long before these brilliant molecules arrange themselves into regular forms; and, finally, the whole mass becomes pervaded by thin crystalline laminæ, which intersect it in every direction, and form projecting crystals in the cavities. The hardness of the basis seems to continue nearly the same; but the aggregate action of the basis, and of the imbedded crystals, on the magnetic needle, is prodigiously increased. It appears to possess some polarity; and minute frag-

ments are suspended by a magnet. Its specific gravity is somewhat increased, as it is now 2.949. The crystals contained in it, when examined by a microscope, appear to be fasciculi of slender prisms, nearly rectangular, terminated by planes perpendicular to the axis; they are extremely brilliant; their colour is greenish-black; they are harder than glass, and fusible at the blow-pipe; they are suspended by the action of a magnet. They are arranged nearly side by side, but not accumulated in thickness, so that they present the appearance of broad thin laminæ; they cross one another at all angles, but always on nearly the same plane; and the lamina thus formed is often three or four lines long, and from a line to a line and a half broad, but extremely thin *.

It seems obvious, that an equalized temperature would have rendered the whole similar to the substance last described; and it may be fairly inferred, that by a continuance of heat, the minute crystals would have been augmented in their dimensions, by the accession of molecules still engaged in the basis, or by the union of several crystals, till they acquired sufficient magnitude for their nature to be absolutely determined by the usual modes of investigation. It is probable, however, if such precautions had been taken as might have secured this degree of perfection in the ulterior result,

* It may be observed, that the cavities which existed in the glass are not obliterated during the subsequent processes, though their interior surfaces undergo some change. The minute globules first formed often become prominent, and project into the cavities. These minute points are soon obliterated by the large curves of the fibrous spheroids, which give a mamellated form to the interiors of the cavities; and, when the crystals are generated in the mass, they shoot into some of the cavities, and line them with their brilliant laminæ.

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that the mass would only have exhibited an uniform aspect; and that the interesting initial phenomena would not have been discovered *.

There are some considerations which appear to offer a partial explanation of the formation of the globules, and of the radiated spheroids. It is well ascertained that heat is emitted by all bodies, in their change from a gaseous to a fluid state, and also in their change from a fluid to a solid state. It is reasonable to suppose, that heat may also be emitted in those changes of arrangement which affect the internal texture of a body, after it has attained an apparently solid state. That a succession of such changes does actually take place, appears to me demonstrated by the appearances I have described, and by the increase of specific gravity, which seems to keep pace with the internal changes of the substance. It would appear, that these changes are caused by a gradual diminution of temperature, which permits certain laws to induce peculiar arrangements among the particles of the glass. When several of these particles enter into this

* In this and the succeeding paragraphs, the word molecule is used in the sense assigned to it by Hauy and Dolomieu, and is understood to represent the peculiar solids, of definite composition and invariable form, the accumulation of which, forms the crystals of mineral substances. Such molecules, preserving their form and their essential characteristics, may be extracted from most crystals by mechanical division, and may be subdivided as far as our senses can recognise them. Though we cannot by mechanical means directly divide them into their elementary particles, we are enabled to effect this by chemical solution, the only power to which their aggregation yields. It will be evident, from the observations that follow, that I am inclined to adopt the ingenious idea of Dolomieu, that many apparently homogeneous rocks are compounds of the minute molecules of several species of minerals; and that, where a suitable opportunity is given, these will develope themselves by the formation of their peculiar crystals.

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new bond of association, they must form a minute point, from which heat must issue in every direction. That heat will gradually propagate itself, till the temperature of the glass is equalized; and then the recurrence of the circumstances which induced the first particles to arrange, will cause other particles to arrange also, which the attraction of aggregation will dispose round the point first formed. A second emission of heat in every direction will take place; the temperature will again be equalized; and again another concentric coat of arranged particles will apply itself to the little globule. But, at the time when the central point of this globule was formed, the equality of temperature, in the mass of glass, would probably cause a number of similar points to be generated. The formation of each must proceed in a similar manner to what I have described, till their surfaces touch, and all the glass be converted into the same substance.

These globules are therefore formed of concentric coats, but they are also radiated. Every one must have remarked the connection that almost uniformly exists, between the radiated structure and the formation by concentric coats. There are few radiated substances which are not divisible into concentric fragments; and as few concentric arrangements which are not radiated. Of the first, it may be sufficient to mention hæmatites; of the second, calcareous stalactites. The tendency to this union of structure, may perhaps be produced by the radiation of the emitted heat, or moisture, if the solution be aqueous; and the divisions of the coats will naturally take place at those pauses in the accumulation of particles, which the momentary emission of heat necessarily induced.

TO BE CONTINUED IN OUR NEXT.

Inquiries respecting the tinning of Copper, Pewter, and Pottery. By M. PROUST.

(Concluded from Page 217.)

M. FOURMY has published, in the Journal de Physique, vol. LV. a memoir on glazed pottery and other baked earthen-ware *.

I freely confess, that if I was extremely well pleased on perusing that memoir, with the theory which it has given us of the product of our arts in this line, I also saw with much pain that it has lost a little of its merit by the exaggerated opinions which it contains, and which want that rigorous accuracy from which a disinterested author ought never to depart †.

I do not see how the author can justify himself from the charge of exaggeration. He condemns without exception every kind of pottery, the English as well as the rest, and assures us that, not to mention their other defects, which are not inconsiderable, it is sufficient that their glazings contain metals to render them more or less dangerous.

* See the fourth volume of the present series of this work, p. 141.

† M. Proust transcribes here several passages from the memoir of M. Fourmy. This memoir is too well known in France for it to be necessary to insert them, and the more so as they are sufficiently indicated by the critical examination which follows. It is not necessary to apprise our readers, that we are far from being of the same opinion with M. Proust on this subject; they will soon perceive, that if the inventor of the *hygioceramės* (wholesome pottery) has exaggerated the dangers of the metallic glazings, though he says in express words, *it would be exaggeration to pretend that a glazing which contains lead cannot possibly be innocent*, M. Proust has not less exaggerated the grounds of security in the use of glazed pottery in general, whilst some has been met with in commerce, which had all the appearance of the English clay, and which formed with vinegar acetate of lead, of which he himself cites an example. Note of the French Editor.

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But would it not be better to set aside generalities which prove nothing, and to demonstrate their unwholesomeness by facts. To announce to the public that the *wholesomeness* will distinguish the *hygioceramtes* of the author, or the new glazed pottery which he manfanctures, from all other *glazed pottery and pottery that contain dangerous metals*, is really doing nothing more than giving a bad name to the productions of others, in order to recommend his own; but this is not demonstrating that ours are *toxicoceramtes* (unwholesome pottery.) Accordingly the complete security in which Europe remains in this respect, notwithstanding the publication of a memoir which appears to have been calculated to alarm it, is a proof that M. Fourmy, who has otherwise treated this branch of industry in a learned manner, has not yet obtained the confidence of the public in what he says relative to their insalubrity; and as long as his hygioceramtes shall not be distributed over all Europe as substitutes for the ware which he condemns, all the world will continue to use the English pottery *.

But let us resume the examination of the opinions of M. Fourmy.

In the first place, arsenic is never employed as an ingredient in the glazing of pottery. If the painter who decorates it puts it into some colour, into the cobalt for example, in order to heighten its beauty, the arsenic is volatilized during the baking. This cannot be doubted; however, the name of arsenic is very well calculated to

* As the author has given so many proofs of sound logical reasoning, and is certainly not ignorant how slowly the most useful inventions make their way with the public, how could he conclude that that of the hygioceramtes was opposed by general opinion, because it had not within a few months supplanted the productions of the manufactories of all Europe. Note of the French Editor.

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strike an alarm. Could this be the design of the author? I should be unwilling to believe it.

The other colours are applied with iron, tin, copper, lead, antimony, manganese, gold, silver, &c. The glasses of lead and of borax serve as their flux, and among these oxydes, those of lead, of copper, and of antimony, can create suspicions only with those persons who are ignorant that the vitrifaction causes their solubility entirely to disappear. Have lemon-juice, verjuice, vinegar, sorrel, salt, or the fats, ever been known to carry away with them any particles of these oxydes? Has any one seen the colours of the glazings dissolve or disappear suddenly or in the course of time, even after many years? It is the friction of the knives and forks, and the scowering with sand, which continually wear off the enamel; but the aliments cannot do it, since they cannot dissolve it *. This is a fact which is open to the eyes of every one.

Sometimes oxyde of copper is mixed in the glazing to give it a green tinge; this colour is applied to the outside of the ware, generally for soup-dishes, coffee-pots, cups, &c.; but it is always so well dissolved and vitrified by the oxydes of lead, of tin, and sand, that there is no example of the aliments having carried away the smallest portion of it. The glazings which are liable to crack and separate in small leaves, and which open a passage to the liquids, whereby they penetrate into the paste so as to spoil and contaminate it with a burnt taste, which, in short, have all the defects with which M. Fourmy re-

* It is far from being an universally admitted principle, that the vitrified oxyde of lead is unattackable by the vegetable acids, with the aid of heat. In a subsequent note a proof shall be adduced to the contrary, which M. Proust will not be able to controvert. Note of the French Editor.

proaches them, keep nevertheless with all their colours as long as the pottery lasts.

With respect to the white glazing composed of oxydes of lead, of tin, of sand, and of salt, how should it be capable of being attacked by the alimentary acids, since nitric acid, at 30 degrees, when kept in a plate of glazed pottery for the space of forty-eight and sixty hours, cannot separate from it any metallic parts capable of being estimated, nor even deprive it of its brilliancy.

I have found some glaged pottery from which nitric acid, after having remained in it for a long time, separated some lead, but in such small quantity, that the sulphate of potash was unable to precipitate it: it required the application of a stronger and more certain re-agent, such as sulphurated hydrogene, in order to render it perceptible.

The more common pottery has, in this respect, the same advantages as the best. We must take care not to confound it with mere glazed earthen-ware, which does not by any means equal it, since the glazing of the better sort receives two vitrifactions; the one for the purpose of affecting the reciprocal solution of the three ingredients which are employed in it, and the other to fuse the glass which results from it, and which remains upon the surface of the paste. This enamel, though more surcharged with lead, and more tender in the vessels destined for cooking victuals, than in those which serve only for the table, acquires nevertheless the property of preventing the action of the acids, by reason of the hardness which the vitrifaction has communicated to it, and the smoothness of its surface. In order to corrode it, it would be necessary to reduce it to powder, and to boil it with the acids. In that case it would certainly dissolve; for the hardest glasses cannot resist this operation.

Moreover,

Moreover, as we do not eat any thing prepared with nitric acid, there is no instance of our glazed pottery, either fine or common, having communicated to the aliments any thing that could prove injurious even to the most delicate health. We may therefore continue to use all wares of this kind with the utmost confidence, and as long as the arts shall not have furnished us with any more perfect, we may safely say that we eat out of *hygiocerames.*

I shall now reply to the fourth assertion of M. Fourmy. The lustre of the glazings is an effect inseparable from all glass, of whatever kind it be, or of every bath of glass well fused upon the paste. This is a quality very independent of the oxydes of lead, and which will never enable us to judge whether the latter abound more in one glazing than in another. As to the colour, which he says is of a disagreeable olive cast, I ask the readers who see this ware daily upon their tables, whether they have ever formed the same opinion.

Let us consider the fifth assertion. If this glazing be capable of resisting the nitric acid, how should it yield to that of the lemon, to vinegar, and to verjuice? It must be admitted, moreover, that the disasters which are occasioned in course of time by this poison are very slow, and very rare; for we never hear of any physician being called in order to stop the progress of accidents occasioned by the English pottery.

M. Fourmy advances, in his sixth assertion, *that hard bodies scratch this ware.* The point of the knife would need to be well steeled, and to be applied with great force, in order to produce any scratches in this glazing; but scratches are produced also upon silver, crystal, and porcellain. Are these defects sufficient to authorize a proscription of the English pottery? The liquids pene-

trate into the paste, &c. This is a defect that has been observed in the pottery of the manufactory of Pont du Choux, at Paris; but it is only a supposition with regard to the English pottery.

He assures us, in his seventh assertion, *that these wares have little durability*. He is sure that if we let a plate fall to the ground it will break to pieces; and certainly it is only these accidents that prevent our seeing the destruction of the glazing. Would the hygioceramos of Fourmy last longer in this respect than a plate of pottery.

Finally, he concludes, in his eighth assertion, *that he has demonstrated that both of these kinds of pottery are dangerous.* M. Fourmy is in the right as to the first: it is a fact which has long been known to all Europe; but as to glazed and English pottery, their reputation has hitherto not suffered the slightest blemish.

Latterly the application of glass in powder for glazing pottery has been announced as a new discovery. This happy idea belongs to M. Chaptal, who, since the year 1789, has put it into execution in his manufactories.

I hope, he says, that if this process is introduced into the workshops, it will soon receive every degree of perfection of which it is capable: two powerful motives ought to induce the artists to occupy themselves with it. The first is, that this glazing is attended with [illegible]nger; the second, that it is less expensive. The [illegible]rest of the public, and that of the manufacturer, both afford reason to hope that it will be adopted, and I hope that the period is near at hand *.

Conclusion.

* This passage, of which M. Proust does not mention the source whence he has taken it, is to be found in a memoir inserted in the second volume of the "Annales de Chimie," p. 75. The use which he makes